AC 2012-3271: A COLLEGE-INDUSTRY PARTNERSHIP: THE MULTI-DISCIPLINARY MASTER'S OF SCIENCE IN ENGINEERING

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Rob Wolz, Director, Project Engineering - Advanced Aircraft Programs, Gulfstream Aerospace Corporation, Savannah, Ga., received a bachelor's of science in aerospace engineering from Mississippi State University in 1982 and a master's of business administration from Georgia Southern University in 2001. Wolz has worked for Gulfstream Aerospace Corporation since 1982. From 1982 through 1987, Wolz worked as an Aero/Performance Engineer assigned to various tasks within the company's Flight Sciences Department. Wolz was assigned to the company's Preliminary Design Department in 1987. He was promoted to engineering manager in 1992 and the department's Director in March of 2003. In this position, he focuses on coordinating and contributing to the conceptual design and evaluation of future Gulfstream product opportunities. Over the past 18 years, Wolz has participated in, or led all of Gulfstream's conceptual vehicle design studies. Currently, Wolz is the Director of Project Engineering for Gulfstream's Advanced Aircraft Program Organization. His responsibilities include leadership of the New Product Development Project Engineering Team, requirements management, and systems Integration and cross functional leadership. Wolz is an Associate Fellow of the American Institute of Aeronautics and Astronautics (AIAA) and has served in leadership positions at both the local and national levels. He has served as Chapter Chairman, Public Policy Officer, Membership Chair, and Council Member. He as also served as the Deputy Director of Public Policy for Region II, and as a member of the AIAA's Technical Committee for Aircraft Design. He is a charter member of the Gulfstream Management Association, a member of the Engineering Advisory Committee for Mississippi State University, a past member of Georgia Institute of Technologies Aerospace System Design Lab Advisory Board, and a past member of Georgia Southern Universities Science and Technology Advisory Board.

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Frank Simmons III, Ph.D., P.E., is the Structures Staff Scientist - Technical Fellow at Gulfstream Aerospace. In addition, he is the Lead FAA Structures AR. He has been with Gulfstream for 31 years, serving in various technical and management positions. He is a co-recipient of the 2010 JEC Composite Innovation Award, the 2008 Aviation Week and Space Technology Magazine Laureate Award for Aeronautics/Propulsion, and nominee for the 2007 Aviation Week and Space Technology Magazine Program Excellence Award. He has performed research for both DARPA and the Air Force Research Laboratory with emphasis on innovative structural design concepts. As Structures Staff Scientist - Technical Fellow, Simmons is responsible for the oversight of all structural activities across all projects at Gulfstream. In addition, he has been extensively involved with the direct effects of lightning on the airframe and fuel tanks design. Recently, his primary focus has been the certification of the G650 with special emphasis being certification of all composite structure.

Timothy D. Farley

Tim Farley, VP Engineering, joined Gulfstream Aerospace in 1992 as a Design Engineer, and since then has participated in the design and certification of all subsequent Gulfstream civil aircraft and numerous military variants. His past responsibilities included leadership positions in structures, service engineering, and Project Engineering. In 1993, he was selected to be Project Engineer for the Gulfstream V Powerplant development program. As Project Engineer, he was responsible for the specification, design, analysis, integration, test, and certification of the GV propulsion systems, including the installed engine and all its ancillaries systems. In 1997, he moved on to be Project Engineer for Aircraft Systems in the Service Engineering group where his responsibilities focused on in-service issues for all Gulfstream products. This included working with customers to resolve any problems or meet any special requirements the customer may have, as well as, ensuring that these designs met company and FAA requirements. In late 1998, he was selected to manage the entire Service Engineering group, increasing his responsibilities to all aspects of the Service Engineering group and including technical leadership and direction for the department. In 1999, he became the Director of Project Engineering. As the Director of Project Engineering, he was responsible for all aspects of project engineering. Providing technical and managerial leadership in the areas of R&D, special missions, and engineering operations (facilities, IT, process definition, etc). During the G450 and G550 development programs, he took on the duties of Project Engineer for the programs. Following the G450 and G550 programs he has been responsible for co-chairing large cabin PCMT and the RQAAT process to ensure best utilizations of engineering resources towards corporate goals. Currently, he is Vice President of Engineering and has taken on the role of PARE Committee Chair person. Prior to joining Gulfstream, Farley was employed at McDonnell-Douglas Company in Long Beach, Calif. He received a B.S. degree in aeronautical engineering from Embry-Riddle Aeronautical University in 1986 and a M.S. degree in technical management from Embry-Riddle Aeronautical University in 2002.

A College-Industry Partnership:

The Multidisciplinary Master of Science in Engineering

[An educational collaboration between Gulfstream Aerospace Corporation (GAC)
and Embry Riddle Aeronautical University (ERAU)]

Background and legacy

Since the end of World War II hundreds of professional engineering leaders have voiced their fervent beliefs before the U.S. Congress, [1] by way of conference addresses, [2] as part of public speaking engagements[3] as well as communicated in a multitude of publications[4, 5, 6] that engineering education in the USA has traveled off course relative to the needs of the industries it serves - the same industries that represent the employers for the majority of the graduates they produced. The assertions being that, as a whole, the educational system has fallen short in STEM education. Oddly universities and institutions[7] appear to produce competent scientists and mathematicians but they deliver only mediocre engineering graduates when considering practitioner needs. Decades back some forecasted an erosion of the nation's ability to technically compete in the emerging world market. Others warned of serious losses in market share that would be accompanied by economic downturns in the U.S. and subsequent job shortages. Today much of that prognostication appears to have materialized.

Over the years opinions varied, sometimes disagreeing, as to the best remedies for turning engineering education more toward the costumers' needs (i.e. industry) but always there was a common call that action of some type was crucial. In a few instances suggestions[8] were offered on how changes could be made. As often happens, some groups appealed for increased government spending to create more educational opportunities at all levels[9] – solutions that evidently proved ineffective. More recently endeavors like the 1990 MIT CDIO Initiative[10] (Conceive, Design, Implement, and Operate), formulated in response to the education drift away from engineering practice, was put forth as an organized grass-roots world-wide effort to change the way engineering could be taught, attempting to insert application relevance into curricula. CDIO today claims over 50 collaborating institutions in over 25 countries worldwide. Defined expressly to support industry's wants, it has come to be championed largely by retired engineering industry leaders and university faculty members with substantial industry experience. The CDIO Initiative, while expanding, regularly encounters institutional faculty who are indifferent to its philosophy, something that has worked in opposition to extensive CDIO adoption. In perspective, there are 520 ABET accredited engineering programs in North America alone, not counting Canada or international schools. Most of these have no concept of the CDIO mission. U.S. engineering programs currently enroll over 70,000 students and only a handful of those enrolled have the opportunity to experience the valuable practitioner insight lessons CDIO offers. So CDIO is a success but it only touches a very small fraction of the total student population.

Other attempts to make alterations in curricula content have focused on systemic educational changes in science and engineering that include K-12 populations, calling for a variety of actions for improved teacher preparedness and enhancing available resources –again to be government funded. There is no doubt that, on a national level, the math and science performance in K-12 educational units for decades has been declining in comparison with many of our world counterparts. There have been ongoing discussions regarding this decline but only a few original plans offered to correct it, so, as things stand today, the decline remains unaffected. To some degree the observations presented here regarding the preparation of educators and working professionals in engineering may also provide clues for ways to reverse the trends in our education system in general.

This paper, however, is focused on engineering education and its needs. It has been written collaboratively by four individuals who have lived through the educational metamorphosis at the various stages that transpired since the end of World War II. They are also devotees to the historical aspects of creative engineering and are themselves accomplished aerospace engineering professionals. Much of what ails engineering education applies to some degree to K-12 STEM issues and in many ways is likewise in need of solutions that can actually be realized. The origins of formal education are traceable to centuries past where each generation tried to pass on social/cultural values, traditions, beliefs and skills to the next generation in hopes of improving opportunities for their success in life. It was not until around 1850 that most of the country began to see worth in organized training and education among their populace for the value it added in the individuals' ability to prosper and contribute to the community. It was during that timeframe that general education, usually state or privately funded, became prevalent.

Education has evolved as a "system" that promotes teaching in abstract pedagogies with instructional strategies to measure performance against expected outcomes but not necessarily towards applications to life's uses or individuals' preferences. In their book "Creative Problem Solving" Edward and Monika Lumsdaine[11] present many stimulating contrasts between our information-based edu-system and creative learning. Education is a system that defines what and how-much one should learn and from what sources; teaching focused, not learning focused. In a parallel sense, one historical perspective delving into the dichotomy of the engineering practitioner as contrasted with the educators' predilections that teach engineering was offered in 1993 by Hazen and Ladesic.[12] They tracked the changes of the aero-engineering curriculum from the 1920's forward to 1995. Interestingly, they noted that the majority of the early engineering programs resembled professional schools somewhat parallel to today's schools of architecture where consummate practitioners were responsible for the majority of instruction. This model continued with little change up through World War II. And then, with the publication of the 1955 ASEE report from the Committee on the Evaluation of Engineering Education, the launch of Sputnik in 1957 and a series of failures in the USAF Pioneer launch program, a major change began that not only altered engineering curricula but introduced an evolution in the composition of the U.S. engineering faculties. In their concluding remarks Hazen and Ladesic wrote: "*Engineering, unlike other professions, has entrusted the preparation of new entrants to the field to educators rather than practitioners*." They go on to describe two cultures starkly different but claiming a common moniker – *engineering*. In essence they had identified the ethos of the academy and industry as culturally dissimilar - each having separate values, languages of acronyms and requirements for advancement; all of which obstruct collaborations and communications between them. They concluded: *"The gap between practice as typified by design and academe as typified by the scientific approach has grown too great. Closure will depend largely upon the willingness and ability of young academics to assimilate the industrial point of view and to build bridges between the two cultures. It is critical to the well-being of the profession, and indeed to that of the nation, that all of the entities involved, universities,* *industries, professional societies, and accreditation organizations work together so that this can be accomplished."*

In a 1996 paper of the Journal of Engineering Education titled "Industrial Experience: Its Role in Faculty Commitment to Teaching,"[13] James Fairweather and Karen Paulson made and excellent case regarding the indirect harm to US-industry competitiveness that could result from having university faculty too focused on research, absent any applied industry engineering work experience, and also not on teaching excellence. This lack of focus was noted especially in the areas of practical applications tuned to the needs of the industry professional. In one observation Fairweather and Paulson state: "*Many faculty and administrators, even students, consistently have commented during the five years of ECSEL (Engineering Coalition of Schools for Excellence in Education and Leadership - were the National Science Foundation funded coalitions to reform undergraduate engineering education, which adopted as its mission a philosophy of to address the incorporation of design throughout the curricula) that faculty without experience in industry are typically less prepared to teach design. Faculty members, especially those hired in the past decade, are thought of as scientists first, engineers second.*"

The current status of undergraduate engineering preparation in the USA

The analysis is presented to make a case that we have evolved an educational system where, in the instance of general public education, we deferred teaching responsibilities to pedagogical specialists that have experienced little which can be tangibly related to meaningful practical applications. Similarly for engineering education we find that we have entrusted the preparation of the entry-level engineers to "academic scientists*" rather than to qualified practitioners.

*[*academic scientist* – a well-educated individual holding a terminal degree in engineering, mathematics, or science; a champion of the scientific method as it applies to altruistic research (usually theoretical in nature) with very little or no professional industry work experience, and no formal training in the teaching arts, or experience in instructional sciences.]

Consequently student graduates find the professional landscape drastically different from their environs of college and the skills they need for success as a professional are not those they used in school. This situation subsequently yields the need for a "transition period," which can be as long as three years after graduation, to have individuals mature their abilities so they may make useful contributions in company pursuits and be entrusted with technical responsibilities. Statements from supervisors who deal with entry-level engineers describe what they see as application-awkwardness, a trait which limits the degree of responsibility they are comfortable giving to their novice workers. Supervisors note new hires overwhelmingly depend on the computer and commercial codes for tackling even simple problems that can be readily approached using pencil and paper. They also harbor reservations regarding the young engineers' effectiveness in completing assignments on time.

Important elements needed in engineering and education

To be a successful engineer takes much more than college degree. Many new college graduates full of energy, excitement, and enthusiasm quickly find on their first job just how little they really know about engineering. They quickly realize that their undergraduate degree has provided them with an appreciation for technical fundamentals and principles of science and has shown them they can be successful learners – all good achievments. Their undergraduate degree, however, has all too often not prepared them to step into the engineering profession or be productive on day one. Many skills must still be developed on the job. This is likely to always be true to some extent, but there are educational activities that could accelerate the professional maturation process.

In the words of Gulfstream's Rob Wolz, Director of Project Engineering: "*New engineering professionals at Gulfstream do not have formal training needed to contribute to the business at hand. A bachelor's degree in engineering is a minimum requirement, but does not fully prepare an individual for the rigors of the day to day engineering profession.*

Basic orientation is all that is provided to all employees. Much of the specifics of engineering at Gulfstream have to be learned 'on the job.' Some practical areas that are often not adequately address in today's undergraduate curriculum are business savvy, creativity, and innovation. These are skills that must be practiced and honed in order to truly be successful."

Gulfstream, like most U.S.-aerospace companies has used a number of different strategies over the years to support education and ensure a pipeline of talented new employees (a rigorous coop-program, support/participation in senior design projects, and collaborative work with students and faculty) with varying degrees of success - some have worked, most have not. These activities have enabled Gulfstream to focus on problems that are meaningful to current new product developments while fostering marginal working relationships with academic scientists and their students. Limited interactions between industry practicing engineers, faculty, and undergraduate students exploring topics of Gulfstream's authorship has provided insight to ways for all participants to gain a greater understanding of the product development environment. Gulfstream-inspired senior projects provided one way for students to broaden their perceptions and learn some of the jargon and concepts associated with applied engineering prior to receiving their degree, which somewhat helps in their professional preparation. More importantly these activities have nurtured working relationships with a number of academics and their students from different educational institutions. In some cases this has also enriched the faculty members' experience where the information gained subsequently found its way into the classroom as part of their teaching. It should be mentioned that the faculty members most receptive to taking part in these activities almost always have been those with industry experience and who already value and share personal experiences with their students. Unfortunately this group represent a small percent of all those teaching in most engineering programs. So the challenge remains; finding ways to engage engineering faculty who are otherwise indifferent to industry involvement or predisposed to research and not interested in practitioner concerns.

Over computerization

The singular dependence on computers and more recent trends to automate engineering in colleges and within industry has produced what is termed here as "over computerization." This tendency, when applied to the more rudimentary engineering tasks, is having a significant impact on engineering productivity and the current engineering products that are emerging in the market today. Often problems, that in earlier times would have been parsed out, simplified from very abstruse requirements, and subsequently solved swiftly on paper, are now routinely approached using complex simulations, 3-D parametric models, finite element models dynamic models, and CFD models. All of these often require days, even weeks, to build, properly check, and debug and then even more time to execute and decipher results that oftentimes are confusing or disquieting or just plain wrong. Output from models has replaced what served engineers for decades; free body sketches/diagrams, kinematic & force diagrams, exercising engineering judgment, and other applications of physical laws and engineering principles along with hand computations, And now there are commercial computerized analytical tools that bridge codes claiming to produce design optimizations - having codes load data into computer models that are used to compute results and pass them to yet other coded models - all at the click of a mouse and without disciplined oversight, all simple to apply and disturbingly gaining popular acceptance.

There are indeed great advantages to computer-aided engineering. Massive amounts of data can be generated, manipulated, and stored, repetitive computations can be expedited, case studies - once formulated and checked - can be rapidly exercised to produce comparable results for decision making, files can be searched and sorted for quick reference. But all these activities should be considered tools to aid the engineers in their work. Computerized solutions are not advantageous and may even border on dangerous if they are used as a replacement for engineering judgment and sound deduction or worse when they are employed to solve problems for which the user has no idea how to otherwise address or no discerning way of determining if the solutions attained are reasonable or correct. Computer applications are also detrimental and inefficient albeit less disastrous when they lead to large amounts of time wasted or generate large amounts of unnecessary data all of which add to increased engineering costs.

All this leads to a question: what are the collective consequences resulting from the general acceptance of widespread computerization in engineering product development? More aspects of the total design can be included early in the design process, which is good; but the process is more difficult to schedule and cost, which is bad. The non-recurring engineering cost for design projects today as compared to earlier approaches has significantly changed and has increased in both percent cost and time from design to the finished product. This was intentionally implemented when concurrent engineering and integrated product teams were launched 30 years ago. But today we find computations are sometimes executed because they can be and not because they are needed. And since they are done they must be documented in voluminous reports filled to the brim with superfluous data. To generate this amount of data either requires more engineers to do what had been done by less in the past or extended times to completion. Either way, more nonproductive recurring cost is generated to essentially achieve the same outcome, but the often buried in stacks of unintelligible data. The time to design completion becomes artificially longer generating questionable information but not necessarily more effective with the negative results of protracted schedules.

To be fair, engineering personnel today have outstanding abilities in creating highly complex 3D models that are superb on the computer screen but the actual products generated often overlook manufacturing vagaries and return to haunt their creators. In the past aircraft components created and sized by experienced engineers with specifications that use standard processes and materials. These would be passed through to detailing design specialists and then on to the shop for fabrication with multiple checks and lots of experienced eyes inspecting them along the way. It was during this flow-through process where the tolerances necessary for manufacturing and particularly assembly were validated by skill and experienced craftsmen to properly fabricated the detail parts and assure correct fit in final assembly. Modern capabilities in 3D parametric modeling coupled with advances in high speed machining has drastically reduced what was formerly required in touch labor, dimensional checks, and related recurring manpower requirements. In contrast, today parts can be accurately defined at nominal size embodying all dimensional attributes with geometric tolerances attached as related information. However quality is established in the assembly of parts that compose a compound product, but assembly variational requirements have yet to be effectively included in 3D computer models[14] and must be added subject to the judgment of the designers. Thus, product quality assurance has moved up the delivery chain to the engineers' workstations thereby shifting quality responsibilities to the engineers and adding more non-recurring cost to the engineering environment. This process, often labeled part of concurrent engineering efforts, has been embraced by industry with one glaring defect that is now obvious; young engineers, as different from those formerly in the delivery chain who have since left the workforce, have little to no practical product applications experience to fall back on in assimilating design decisions or assuring producible assemblies with acceptable quality but yet they have vast design authority and control through the computerized elements they create. It is submitted here that these difficulties are aggravated by the lack of awareness regarding manufacturing realities in delivering education particularly at college levels.

Other aspects of over-computerization may add additional hidden costs. Currently engineers appear to have difficulty seeing the 'big picture' of a problem due in part to the artificial boundaries the computer landscape, the monitor screen, and the programs impose. The ability to formulate a problem with pencil and paper to large and small scales then ably see the big picture beyond the computer color contour or spreadsheets and small monitor screens has already resulted in tragic consequences. In his book, "Engineering in the Mind's Eye," Eugene Ferguson discusses such instances have already resulted in major problems. Due to the over-computerization, the judgment of engineers has become compromised. Ferguson cites the following in this work: "*Despite the enormous amounts of effort and treasure that have been poured into creating analytical tools to add rigor and precision to the design of complex systems, a paradox remains. There has been a harrowing succession of flawed designs with fatal results – many of them afflicting the projects of the patron that so clearly saw science as the panacea; the Challenger, the Stark, the Aegis system in the Vincennes, and so on. Those failures exude a strong scent of inexperience, or hubris, or both, and display an apparent ignorance of, or disregard for, the limits of stress on materials and people under chaotic conditions. Successful design still requires the stores of expert tacit knowledge and intuitive 'feel' of experience; it requires engineers steeped in an understanding of existing engineering systems as well as in the new systems being designed."* The conclusion Ferguson reaches is that computerization is not the problem but has become the enabler to the problem. Their implementation has attained new levels of achievement as long as they are used judiciously in the context for which they were intended and as tool when needed. However the escalating trend throughout academics for computationalizing every branch of education is inescapable to the students being taught. Students can only presume what they observe and learn in college, relying intensely on the computer, will serve them well in the profession; it may not.

The generations of engineers that are currently being trained by our universities have these fantastic tools in their hands, usually in newer versions than found in industry. Every conceivable computational tool is literally a mouse-click away. They are taught quite well to compute solutions to problems as presented to them in exams and homework. Their ability to approach the solution to engineering problems is predicated on information being instantly available. But in reality honest engineering designs never occur in textbook form and there are sizable gaps in the context and information available; there are a mix of multiple disciplines that merge into a single design. The intent of the MMSE presented in this paper is to bridge the gap between academics and industry at least at one institution to enable the students to bring together the ability to assimilate information from a wide source of disciplines and formulate a solution, to be able to create the "tacit knowledge and intuitive 'feel' of experience" as Ferguson describes above. The difficulty is finding effective ways of enlightening the educators to accomplish this. If the ever increasing reliance on computerization in every aspect of engineering becomes even more the standard, the next generation of engineers who become the next generation of engineering managers will be at a crossroads that could significantly challenge them. To make the decisions necessary for successful product design they will need to be able to draw upon their own experience and intuition, something that they would subconsciously do. What if the experience and intuition isn't there?

Having applicable experience plus intuition and the consequence of its absence can be illustrated by citing the experience of General Paul van Ripper's as described by Malcolm Gladwell in his book, *Blink.*[15] General van Ripper was assigned as the commander of a force as part of a war game simulation. Van Ripper, a seasoned veteran, was to command a group that was to oppose a fictitious army where he was to encounter the entire might of the U.S. Navy and Marines. At the conclusion of the simulation, General van Ripper had in essences sunk an aircraft carrier, two cruisers, and a destroyer and prevented the Marines from conducting a planned assault. Gladwell did actually interview the General and asked how the he had managed this feat. Van Ripper cited several things but said the biggest advantage he had and the largest disadvantage the "enemy" had was their heavy reliance on technology. Van Ripper knew his adversary's command structure could only operate with the aid of numerous computer enabled analyses followed by lengthy presentations of the outputted results in committee settings with subsequent action items to discuss steps to be taken. He strategically saw this operational scenario as a weakness for them and used it to his advantage. He personally made quick high-level decisions based on his experience and intuition and pushed command actions and control to his field commanders. He used technology sparingly, choosing not to rely on it in the same way his opposition.

While used as an example to illustrate the paralysis that over-analysis can generate, in many ways the issues and challenges for our young engineers are similar in context. They may face situations in the future that could be like those of the opposing forces unable to grapple with the important aspects composing a problem without digital computational aid if the current trends persist. The challenges here are real and time is short. The experiential knowledge gathered over a lifetime by older generation of engineers, the "grey beards", who transited the paper-to-electronic engineering transformation now has a very limited life, knowledge which is rapidly disappearing from the work place and that has all but vanished from the universities. This sage generation has had the experience that future engineers and engineering managers need to learn and to discern when and when not to computationalize their problems at hand.

Internships and co-ops

With professional preparation in college falling short of the mark it is not surprising that the majority of aerospace companies today in the United States prefer hiring individuals who have completed a comprehensive cooperative–education (coop) program or relevant internship over those graduates who have not.[16] It has become a recommendation of a many companies as well as leaders of national professional organizations that all undergraduate engineering students should be involved with coops or internships as part of their education – in fact some corporations (Boeing, General Electric, General Dynamics) have taken the position that colleges need to make coops a mandatory part of the bachelor degree. Unfortunately, the numbers don't add up and the enthusiasm among academics to act as advocates or as advisors is insufficient to support 100% coop participation. Obstacles include the entry requirements for these positions, which come with GPA and citizenship constraints eliminating the almost a third of the bachelors and half masters candidates in U.S. schools.[17] There are roughly 15,000 undergraduates enrolled nationally in aerospace engineering alone, and about only half of which meet the eligibility requirements for positions without considering the other much larger discipline enrollments that also serve the aerospace community (mechanical, computer, software, electrical, chemical, metallurgical, industrial, civil, etc. that add six-times this amount to the pool). So, without considering logistics and financial considerations, there are simply not enough intern/coop positions available to accommodate the undergraduate population to support a mandatory requirement. Moreover, even if total coop/intern participation were plausible, the "root cause" of the professional preparedness issue still has not been addressed. The preponderance of the U.S faculty teaching in our universities do not have a direct or meaningful association with the practice of engineering in the field.[18] For the most part they have never "walked a mile in the shoes" of the entry-level bachelor-of-science engineering graduate who experiences the quirks of the workplace after four years of college education.

Nonetheless, one of the most important new employee pipelines for entry level positions for major corporations including Gulfstream remains the coop program. Coop students' alternate work and school sessions. They rotate work assignments, thereby experiencing a range of engineering specialties. This benefits both the student and the company. Students gain a true understanding of what different specialized groups do within the company and they can begin to develop their career plans and complete the knowledge requirements needed to take on serious technical responsibilities. The company benefits by the contributions of the students. By providing a rich work/training apprenticeships, the company profits by accelerating the training time for new employees, thereby increasing a new individual's productivity. While involved in Gulfstream's Coop Program, participants are treated as full time employees. They work side-by-side practicing professionals. They are given realistic and meaningful tasks that support the company's ongoing activities and long-term objectives. Another important aspect of the Coop program is the expectation that these students will ask questions – thereby making the most of the opportunities provided. Coop experience helps ensure excellent learning and consequential professional growth capability.

College and industry cultural dissimilarities

The majority of engineering degree programs offered in the United States, and most importantly those in aerospace as argued early, have undergone a continuing transformation away from the synthesis of practiced arts. In a half a century we changed from practitioner to scientist until we now are confronted with a status quo where these two worlds of practice and education are so far apart in value and the jargon they speak that they are barely able to communicate in meaningful terms much less work collaboratively and understand each other's needs. How has this happened?

Often the 1955 ASEE Report of the Committee on Evaluation of Engineering Education [19] (AKA: "The Grinter report") is ascribed as initiating the shift in focus from practitioner-oriented to science-focused education. The Grinter report indeed recommended "*More emphasis on fundamental science, on engineering science, and on the broad humanistic and social areas has been recommended than is contained in most engineering curricula*" but also included considerable focus on the need for faculty to be involve in the practice of engineering through meaningful consulting intersections with industry beyond research. Inadequacies in the U.S. engineering and science communities were regularly faulted during the Cold War. A rush to remedy U.S space program failings provided fuel to the arguments that what was being taught as engineering needed changing. With regard to making room in the curriculum for the new science, mathematics, and humanistic material content the Grinter report also pronounced: "*A review of the evolution of engineering curricula over many years shows a trend toward increasing emphasis on the science underlying engineering at the expense of the study of engineering art for its own usefulness. This trend would appear sound for application in the present dilemma,*" And, with excellent intentions in mind, the transformation in the engineering bachelor's education content began.

The shift was also influenced strongly by the economic and political events since the late 50's, which in addition to adding increased humanities, science, and art components to the curriculum - market competition and accrediting strains have force the compression of four-year programs from 140 to 120+ credit hour range. In the wake of reducing engineering content and cost, something had to go. So laboratories, where students (and faculty) gained valuable hands-on experience and learned to use tools and instruments, have almost entirely disappeared. After all, these are resources that require staffing, scheduling, consume major space, involved expensive equipment, require costly supplies, demand maintenance, all while presenting environments that harbor potential liabilities if students are injured – a huge concern in our litigious era. So labs have become "look, but don't touch" observation or simulation exercises normally conducted by graduate teaching assistants – not faculty. Hence the lack of practitioner experience, equipment, and facility funding has led engineering schools to further increase their dependence on theoretical or analytical engineering programs that are less costly. Yielding the theoretically oriented faculties, who are entrenched in an academic value system that compels them to research and publish to advance in rank, who find it difficult to deal with hardware, fabrication and the industrial concerns even if they want to– the corporate culture has become, for the most part, entirely out of the faculty comfort zone, a place different from the academy and the classroom where they are accepted as the most informed on a specific topic among everyone present.

There are exceptions. There are a small number of faculty members who came from industry to the academy and who value the synthesis of practice. These are individuals that have chosen to regularly consult with industry believing "to teach engineering, one should do engineering" – "academic practitioners" of sorts. And it is these exceptions where the best chances for change lie in bridging the cultural gap between the university and industry. Unfortunately their professional consulting activities are often viewed as of low value contributions to the college administrators and discounted by their peers.

Sensitivities in the aerospace-defense education sector

Over time the cultural changes elucidated here have been continuously worsened by the rewards system of academe and also by the slow transformation in the philosophy and interests of engineering academic workforce (the faculty). From the early 1970's onward (the period of the "Crisis in Engineering Education"[20] the graduate population in engineering programs has been dominated by intelligent and capable U.S. and non-U.S. citizens. For decades the non-citizen population has grown because of hiring restrictions in the U.S. aerospace and defense industry, which prevented the majority of the bachelor-degreed non-citizens from entering the workplace. They choose instead to pursue graduate degrees and thus remained in the country as graduate students. Articles were published[21] praising the opportunities and analyzing the possibilities realizable from embracing the foreign-national component as the new graduate-student norm. Cases were made[22] that this was the obvious correct thing to do during the 70s and 80s as teaching positions were difficult to fill from the U.S. grads and undergraduate enrollments were burgeoning. As the numbers of U.S. and non-U.S nationals grad-students grew, somewhat isolated in colleges and universities across the land, their awareness and experiences of the synthesis of practices associated with the profession had not. This trend set the course to the present – particularly for the foreign students component, who through no fault of their own, had little opportunity to gain industry experience but manage to survive in college and now represent more than half the terminal degrees conferred in the nation.

Upon spending seven or more years here as students, many non-citizens acclimate to the American life-style, sought employment, usually taking teaching jobs along with some of their U.S. cohorts in engineering colleges, applied for U.S. citizenship, and assimilated into the faculty ranks. As time has passed, aerospace engineering faculties with rank have become dominated by non-practitioners as the majority at many of our institutions. As could be expected, the reference-frame that these faculty use in deciding curricula content, hiring, and promotion requirements for other faculty is often a natural reflection of their own personal experiences, which has largely been focused on engineering academics/research and not industry practice – they have become "academic scientist." So, after three generations, the academic scientists represent the majority population of most engineering faculties. They are prominent members in segments of ASEE and ABET and many of the professional organizations (AIAA, SAE, IEEE, NAE, NIA, etc.). All firm in the notion these participations constitute "professional participation" unfettered that the composition of the organizations they join are principally populated by their counterparts from other institutions and very few engineering practitioners. These faculties have now become the engineering senior faculty, chairs, deans and chancellors of the universities across the USA – all knowledgeable academics and valuable citizens but not practitioners. They have written textbooks, have helped define the curricula content evolution, and also currently deicide the profiles befitting junior faculty as new hires – and the trend perpetuates.

Impact of widespread outsourcing on overseas suppliers, Of late this tendency has changed a bit with many non-citizens upon graduation choosing to return to their home countries adding to the capabilities of those nations and contributing to overseas outsourcing issues now faced in the U.S. job market. Meanwhile U.S. manufacturers move their sub-assembly manufacturing dependence to overseas sites in hope of realizing reductions in cost-to-build they find their product support engineering workforce there, the major directors of work, trained in U.S. schools. Professional publications are laced with incidents and issues relating unforeseen blowback in the form of inferior workforce capability, missed deliveries, miss-interpreted specifications, substandard workmanship, and slipped schedules not to mention certification difficulties with the FAA or the DOD. Major aerospace companies (Gulfstream, Boeing, General Electric, Lockheed, etc.) have all experienced quality escapes of these types stemming from their suppliers, both foreign and domestic. What was originally introduced as a sound business strategy has turned into a product quality tragedy and is to a large degree related to the lack of good engineering practice and experience regardless of nationality.

College-company interpersonal connection: bridging the cultural differences

A meaningful and valuable strategic connection was made between Gulfstream and Embry Riddle stemming from very serendipitous beginnings. A student-teacher connection formed during a capstone design course in 1986 led to a professional relationship maturing over the ensuing years through intermittent but substantive communications. After 13 years in the profession the alum, Mr. Tim Farley, was working as director project engineering for Gulfstream when he approached his former professor, Prof. Jim Ladesic, with the notion of cultivating a relationship between Gulfstream and ERAU. Like most ideas that are off the traditional path, the inertias that had to be overcome in both organizations made for a slow start. At the time the ERAU-College of Engineering (COE) leadership was uninterested in what appeared to be a technologically focused endeavor – too "techy" for the erudite precepts being fostered at the time; a symptom of the cultural divide. Besides, while other units within the ERAU were well acquainted with education on-line and distance programs, the COE had no experience in distance delivery for engineering and it was easy to say "no." Also, at Gulfstream there was at least apprehension, perhaps even suspicion, regarding the level of contribution that could be actually realized from such a college-industry arrangement, previous intersections with academics had left many of the working managers less than impressed with the deliverables obtained when compare with the impact on their budgets. But the collaboration persisted with schemes that could be adopted within the framework of both organizations.

From 2001-2011 a great deal was achieved that has proven very beneficial for both organizations. In 2001a ten-year PIA was written between Gulfstream and ERAU, which has recently been renewed for an additional ten years. Gulfstream upper managers were invited and participated on ERAU COE advisory committees. Projects were undertaken in the ERAU capstone design classes with critiques conducted by Gulfstream engineers for BSAE seniors. A couple of industry-experienced faculty research projects supporting GAC initiative were successful undertaken and completed. Embry Riddle also proved to be a viable resource for recruiting direct placements for coops and interns, where firsthand recommendations from known faculty help fit applicants with jobs. A series (14 in all) of well received continuing education short courses, sponsored by Gulfstream and developed by ERAU faculty, were presented to the Gulfstream working engineers. This short course endeavor was significant in that it was the first real step in developing a tactic by which faculty could associate with working engineers. Summer faculty fellowships for two faculty were arranged and a three-way collaboration project between Gulfstream, ERAU, and the Savannah College of Art and Design (SCAD), as well as continuing Gulfstream sponsorship of topics and engineering critiques for senior design projects all contributed the a synergistic and symbiotic relationship between the organizations.

Prof. Ladesic is one of ERAU's faculty members with significant industry experience and professional credentials. He became directly involved within Gulfstream through summer and sabbatical appoints in 2003, 2004-5 and again 2010-11. Ladesic readily acknowledges that his involvement with Gulfstream has been personally and professionally satisfying and Gulfstream management has similarly stated they feel it has proved very valuable to Gulfstream as well. With time, a level of mutual trust and respect was established. So it was quite natural during the 2004 visit for earnest discussions to ensue focused on developing a tailored Gulfstream master's degree program to meet workforce development needs.

Motivation for the degree – Gulfstream's Position

The leadership at Gulfstream has long recognized the importance of a well-educated and skilled technical workforce. There have been obstacles to ensuring such a workforce is hired and maintained, one being the company's location. Savannah does not have engineering schools to serve as a source for recruiting young engineering. Therefore, almost all of the engineering staff has been recruited from outside of the area. By nature, most engineers are interested in continuing their education and enhancing their abilities in conjunction with their professional experience. The lack of local engineering schools was a real hiring and retention obstacle to be overcome and was the source of a good share of the employee turnover.

Before establishing the MMSE, focused short-term projects were one means of building relationships and providing educational opportunities. These types of projects were done with a number of schools – Georgia Tech, MIT, University of South Carolina, SCAD, and ERAU. All of these activities were interesting and seen as positive experiences, however, the projects that built collaboration between ERAU and Gulfstream proved to be exceptional. There were many reasons for this, but one fact that clearly contributed was both entities shared a mutual respect and recognized the potential long-term benefits possible for both organizations

From Gulfstream's viewpoint, without hiring, growing or having a means of infusing technical expertise, continued product development and market leadership would be extremely difficult, if not impossible, to maintain. This fundamental business truth is the primary motivation for Gulfstream to endorse and support advanced educational opportunities for its technical professionals. To Gulfstream, it is very important to find an educational institution that is willing to tailor a technical master's program. Such a program needs to focus on the areas deemed strategically critical to current and future Gulfstream interests. It needs to be structured to permit integration within the schedule of working professionals. It also needs to provide the opportunity to evolve into something very much infused with Gulfstream-specific examples.

An engineering approach in developing an engineering degree – Growing the Relationship

Embry Riddle was not the only university that Gulfstream approached to request solutions to meet our development need. Georgia Tech was also considered an excellent potential partner. Logistically they are much closer and assumingly would be keen on wanting to participate with major industry organizations. However, Tech proved to be far less flexible, and far less motivated to team with industry. Like most large universities, their focus proved to be clearly on fundamental research, not on applications or on the development of entry-level engineers and the professional advancement of working engineers. Their priority and business strategy clearly works for them, but it appears to be a stumbling block to the establishment of a workable, moldable, master's program for Gulfstream's technical workforce.

And Gulfstream, like many other corporations, at that time had become unsure of the likely value added from one-way collaborations with academics (funding flows from the corporation to the university with little in the way of useful product flowing back) and more uncertain of the ability the academicians to deliver meaningful substance useful in advancing the competitive positions the companies were pursuing. The primary attribute for deciding to work with ERAU became the willingness of their administrators and faculty to listen, understand, and get involved in the effort with a clear vision of the mutual benefits that were possible. Embry Riddle was receptive to cooperatively developing a tailored graduate degree program, designing it to meet technical workforce development requirements. Essentially ERAU and Gulfstream applied LEAN concepts like those used in product development (including TQM and QFD[23, 24]) to formulate an educational strategy and action plan. From an educational perspective Gulfstream was the customer and the proposed degree the product. It was to be composed so that it met the needs of the customer yet engaged solid pedagogical attributes.

Consistent with Gulfstream's philosophy of continuous improvement, an internal audit by the leadership team had already identified the technology position for the company in various disciplines and targeted those areas thought to be in need to fortification relative to its market. One initiative that resulted from this audit identified areas where advanced engineering education could play an important role in achieving or increasing the proficiencies within specific areas important to the company. During that same time frame Ladesic, while on a summer consulting appoint at Gulfstream, began discussions with the Gulfstream's engineering leadership regarding an education initiative. The outcome was a preliminary wish list of technical topics that could be helpful in furthering the workforce skills needed.

What format: a MS Degree or a Certificate Program? – Running the ERAU Gauntlet

Early debate had revolved around the best approach for inculcating engineering knowledge, skills, and in what format to do so regarding work schedules and projected demands. What levels of rigor would be important and what performance should be assessed? It was concluded that formal MS degree would be best. An organizational meeting between Gulfstream and Embry Riddle engineering faculty and administration was arranged and centered on a number of possible collaborations, one of which was developing a focused graduate degree program. An *Action Item* list resulted from that meeting and personnel from both organizations were assigned responsibilities. As a starting point, topics in fundamental science, physics, and mathematics which could be evolved into content that supported the personnel skills needed were formulated. A first-pass degree general topic list was reviewed by Gulfstream and the COE with shared comments form both.

A Strategic Needs Analysis (SNA) was conducted to identify and focus on stakeholder involvement. A workshop setting was used to define the purpose and to recognize a range of strategic options for this new degree. The SNA provided insight to what program essentials would be and to assist in avoiding problems associated with simply assuming that the client's interests are known. Gulfstream was actively involved in this process (the "voice of the customer"). The SNA "kick-off" meeting was held July 2007 between Gulfstream's executive leadership team and ERAU representatives that focused on developing an educational program leading to a masters-level degree in engineering. It was agreed that such a program be crafted using the topics in hand by the COE in collaboration with Gulfstream and other ERAU components, as required, to be delivered in Savannah. A refined topics list was compiled.

If the preponderance of this new program could composed of currently existing ERAU courses, the logistics, economics, and development efforts in establishing the degree would be simplified. Selected descriptions of existing or planned COE graduate courses that aligned with the selected topics were provided to Gulfstream's representatives for consideration. While not necessarily explicitly complying with topics needed by Gulfstream, the list was representative of the identified areas needed in Structures, Aerodynamics, Propulsion, Software and Mechanical Engineering and were matched against the topic listing in a matrix form for deliberation by Gulfstream.

A second curriculum development SNA workshop was held in October in Savannah where serious discussions yielded a refined program draft. In keeping with LEAN methods, this curriculum, first and foremost, reflected Gulfstream's needs. Courses were identified not only in other science, physics, management, and mathematics but also in engineering sciences and systems that buttressed the needed personnel skills. A draft was constructed to gather topics into legitimate graduate educational components to form a degree draft. The curriculum draft was circulated and reviewed between Gulfstream and the COE with all input integrated into the plan. Over the next year requests for comments from other ERAU university units were gathered and integrated into the proposal. The ERAU Board of Trustees was informed of the proposed plan during both their spring 2008 and spring 2009 meetings and their reaction was favorable.

Other meetings were organized in Savannah where the principle constituencies from both Gulfstream and ERAU met to discuss further pedagogical needs, educational objectives, and more comprehensively define and tailor curriculum content. The draft curriculum was modified to reflect this input along with a pilot schedule for implementation. Challenges were identified in the form of differences in schedules, pinpointing notification times for the plans to be executed, logistic for having ERAU faculty on site at Gulfstream, facilities, software licensure, computers and instructional equipment. Grappling with these items proved far more complex than deriving specifics of the curriculum and were the "next-steps" to be resolved. A draft-program status briefing was held July 2009 with the same Gulfstream personnel of the SNA workshops, along with the University-Chief Academic Officer, the Dean and the key faculty representative of the COE. Customer input from this review led to identifying another feature desired in the MMSE; an interdisciplinary elective thread in flight science control laws that would span the proposed tracks.

Degree requirements and program delivery

Gulfstream's employee candidates for this program would meet the minimum ERAU graduate admission requirements for study in engineering. Degree completion would require 30-credit hours with a minimum 3.0 CGPA on a 4-point system. Candidates would be required to undertake a thesis engaging in research topics supportive of Gulfstream's product developments, methods advancements, capabilities improvement, and business objectives. The thesis would constitute nine of the required 30-hours for the degree leaving the remainder to be achieved through course work or the equivalent. All academic advising and research advising would be under the auspices of an ERAU faculty representative and appropriately qualified Gulfstream's employees. The candidate's thesis committee must include at least one ERAU faculty member as the principal advisor. One of two separate course delivery schemes was proposed to be used, perhaps conjunctively:

1) An ERAU on-site faculty representative would teach a 3-credit course in the traditional classroom format, with assignments, projects and exams, over a ten-week-plus period. These faculty would be either a visiting (On-Fellowship or on-Assignment) member of the full-time faculty from the COE, or an engineering practitioner from Gulfstream, or a local retired professional holding appropriate credentials and approved as an adjunct faculty member. Courses would be offered in weekly meeting formats that support GAC interests and business needs to achieve the equivalent SACS-approved minimum contact time.[25]

2) Once established, ERAU campus faculty could offer courses using distance-learning (DL) technologies or by on-line methods for candidates to use in self-study or real-time involvement for part of their degree requirement subject to student accepting these delivery methods as effective.

Item 2) represents a strategic accomplishment for COE since very little progress had been realized in DL usage in any form in the college since the university had aggressively move into that arena in the early 90s for other disciplines. Some proponents in the COE had regularly voiced concern that motivators and incentives were needed for moving in this direction. The graduate degree at Gulfstream appears to be one way for this to be realized.

University involvement

An ERAU faculty member or a qualified ERAU representative was to be assigned in-residence at Savannah as the Liaison at GAC on a rotating basis. In-residence assignments could span periods from ten-weeks up to 12-months in duration with possible gaps and overlaps depending on other Gulfstream and ERAU commitments. While engaged, faculty would have opportunities to consult, conduct research, and development work important to Gulfstream, teach, and to serve as thesis advisors. The details and financial arrangements would be determined as part of the contract negotiations between the individual faculty member and Gulfstream. Finally, a program status critical briefing was conducted July 2009 with Gulfstream's representatives, the University-Chief Academic Officer and the Dean of the COE. Customer input from this review led to additional features of four technical elective tracks.

A number of different financial and logistical plans were evaluated including an exclusive contract arrangement, a lock-step cohort plan, offering courses on-site at Gulfstream, and so on. Upon deeper evaluation every arrangement proposed that attempted to blend the two business elements of Gulfstream and ERAU proved vexing and fraught with pitfalls because of their differences. For instance, offering courses on Gulfstream's property was, and is, met with complexities and issues that boarder on impossible: citizenship restrictions, security badging for faculty, escorts for faculty on temp badges while teaching, software licensure at full commercial costs, computing platforms needed to teach would have to be taken from either Gulfstream's training area or take away from workers or make it necessary for Gulfstream to purchase new equipment – also the software versions used by industry typically lag that of the University causing problems (faculty would be unfamiliar with the idiosyncrasies of the older code versions and be less receptive to the program in the program) while also missing an opportunity. There also non-trivial regional accreditation (SACS) issues that crop up relative to the appropriateness of the facilities to be used – putting GAC under third party scrutiny they wish to avoid. If the University were on its own property it could supply computers and software used expressly for teaching and take advantage of significant educational discounts and have access to the very latest version of a particular code. Making this available to the students lets the employees see and work with newer versions of software before it is adopted by the company.

Other arrangements considered and discarded included cost-sharing, negotiated term contracts, committed space arrangements with access when needed, and so on. It became clear that there were significant policy, business, operational calendar, and organizational differences at play and it would be best to maintain a clear separation between the two organizations. In so doing a tuition fee per credit hour was agreed upon and it was decided that Gulfstream would adjust their internal policies slightly to accommodate the MMSE for reimbursements beyond their current constraints. Students would apply directly to ERAU and be matriculated as Daytona Beach-campus students. The students would be responsible for the up-front payment of tuition.

A working relationship was developed between the COE and the ERAU-World Wide organization to share facilities near Gulfstream. The COE would be responsible for all faculty cost, expenses, and per-diem and ancillary costs. Equipment and facilities were identified that would serve the MMSE and acquired by the ERAU. In this way what is ERAU's, stays totally under ERAU responsibility and control. ERAU would control the curriculum and all academic decision making, ERAU vets all faculty, licenses software specific to courses being taught for educational use only an keeps it on ERAU property with ERAU-IT support to avoid problems and cost to GAC. ERAU would specify the computers, control the space availability, and the students would register as ERAU students, and pay personal tuition like all students do. When students complete a course they would work through Gulfstream's system for reimbursement consistent with Gulfstream internal policies – ERAU would not be involved. Thesis research topics would be first approved by Gulfstream relative to their interests, needs, and level of financial support needed then they would be reviewed and approved by COE faculty for academic appropriateness – each party having right of refusal within their vested interests areas. Each thesis must have and ERAU-COE faculty member as the committee chair and key advisor. This was the cleanest model to set up – a clear dichotomy of responsibilities while providing functionality toward a collaborative common goal – professional development and education.

The resultant MMSE degree program

With ongoing back-and-forth communications this graduate-level program was finally settled as being a multidiscipline in nature to best suit Gulfstream's needs. It would be available to only qualified professionals practicing in the Gulfstream workforce and initially be a traditional faculty-member-in-the-classroom program. The use of DL and technology enhanced instructional schemes conjunctively with traditional course delivery methods to yield a blended program format would be experimentally phased-in. The term "blended" is used to define a delivery format where some class sessions would be conducted face-to-face and others would be conducted using any of a number of synchronous DL technology-enhanced instructional methods and perhaps including on-line delivery. As it was developed, this engineering program became the first of its type at the University designed to meet the specific needs of a customer's personnel, the company product development plans, and the University faculty professional development. Program goals and objectives were created and agreed to as follows:

MMSE program goals:

1. Add to the number of applied research projects in areas identified with the ERAU legendary core competencies in aviation
2. Involve a larger percentage of the ERAU engineering faculty in viable research areas of interest to Gulfstream and industry in general that can be applied to Promotion &Tenure
3. Increase the number of engineering faculty sabbaticals and internships in industry
4. Augment the graduate faculty ranks in the COE via recruiting of qualified and experienced engineering professionals from Gulfstream as adjuncts
5. Earn research funding and resource support from industry partners for faculty scholarly and professional development
6. Involve a larger percentage of the ERAU engineering faculty in instructional technologies and course delivery methodologies
7. Establish a DL capability for the ERAU in graduate engineering education
8. Boost the graduate student enrollment credits and revenue for the COE graduate programs

MSDP program objectives:

1. Facilitate the professional engineering development and industrial experience for faculty to preserve the ERAU heritage and reputation in applied engineering sciences
2. Provide focused graduate-level engineering education for Gulfstream's employees and affiliates in topics supportive of Gulfstream's product development and business areas for the knowledge and skills enhancement of their workforce
3. Establish an interdisciplinary intra-collegial graduate-level engineering program with outreach potential and expansion possibilities to other companies
4. Enrich our collective reputations as leaders in aerospace and aviation
5. Fortify our relationship between university and industry cohorts through education and research involvement**.** Supply research opportunities for the ERAU faculty pertinent to our niche.
6. Enhance the research potential in meaningful areas identified with Gulfstream's and the ERAU's core competencies**.** Institute DL courses offered from GAC's site to the ERAU residential campus

This 30-credit graduate program is composed of a 12–credit core for all students involved, four focused elective tracks of nine credits and a required research component. The degree is for only Gulfstream direct employees, is focused on areas unique to the Gulfstream's product lines, and is arrayed to advance their working knowledge and skills. The technical Tack Electives are: *Flight Mechanics and Aero Sciences, Airframe Structures and Mechanics, Systems Integration, Interdisciplinary Sciences, Research: (In all cases must have specific Gulfstream development focus)* - Directed research and thesis activity is closely aligned with current employee job function, with Gulfstream's development focus, and that complies with the research interests of associated ERAU personnel involved.

Overcoming university mindsets

The curriculum approval process at the University is well suited for our traditional resident-campus graduate programs that fits into a semester system of 14-week duration with classes meeting two times weekly for a an hour-and-a-half each meeting. As anticipated attitudes had been formed among the faculty predicated on their teaching experiences was the student learning aptitudes that the faculty had observed where based on the majority of the students continued directly from their undergraduate programs to graduate work – following the earlier discussions of this paper. One could say these students are professionals since most are on ERAU assistance of one type or another. The curriculum approval workflow requires a proposal be reviewed for the impact that the new program will have on other existing programs currently offered at any campus unit in the university. Each unit provides comments from all campuses on proposed program impact. The Gulfstream program is structured to fit in a ten-week term that starts a week later than and ends a few weeks before the corresponding campus term. The MMSE proposal encountered heavy conjectural resistance from other unit faculties (Human Factors, Physical Science and Mathematics) taking the position that rigorous scientific graduate material "simply could not be absorbed and processed sufficiently in such a compressed schedule, especially dosed in one-day 4-hour long meetings." Gulfstream works a 4-10 week making Friday a no-work day. Part of the logistics dialogue that, based on the needs of Gulfstream, occurred in establishing this program dealt with the requirement that all classes would only meet on Friday's. (This is related to one of the "inflexibilities" mentioned regarding Georgia Tech – they, like the ERAU faculty, were similarly opposed to any delivery schedule other than what they believe to be appropriate based on their experience).

What remained obscure to the resident ERAU faculty evaluators and commenters was the student clientele for the MMSE are working professionals, accustomed to long hours and meeting schedules, each having a keen awareness of time management and professional focus. They also overlooked that these are full-time employees committed to a 40-plus work week and none of them would take more than one class a term. Further influencing student performance was the Gulfstream's graduated reimbursement incentive as a motivational influence on the desire to preform academically. Gulfstream reimburses as a function of the academic final grade received in a course on a schedule of an "A" equates to 100%, a "B" 80% and a "C" or lower, 0%. Early on, it was debated whether this may be too stringent a constraint but it was decided to uphold the academic performance expectations to a high standard while preserving the reimbursement rule. Not apparent to the reviewing faculty was a realization the Gulfstream holds very high standards when hiring engineers – insisting that most, if not all, serve in a coop or internship and the each have very high academic records and pass muster in a demanding interview process. In addition – to meet and be approved for the internal Gulfstream tuition reimbursement program requires a one year minimum service in engineering. So the MMSE student population is mature, serious, responsible and capable of diligent effort as represented by the data compiled in Table 1 from grades accumulated during the first two years of the of the program. The collective cohort CGPA of 3.86 is 18% above the CGPA for all the on-campus engineering masters programs, one of the performance measures of the excellence.

	Elected Track Enrollments	*Credits Earned*	*Track-GPA*
Airframe Structures & Mech.	16	160	3.89
Flight Mechanics & Aero-Sci.	2	18	4.0
Systems & Integration	9	127	3.88
Interdisciplinary Sciences	11	159	3.81
TOTALS:	***38***	***464***	
Transferred Hours:		6	***Class GPA***
Total hours accumulated:		**470**	***3.86***

Table 1 – MMSE Student Program Performance to Date

Other Measures of performance

So far eight faculty members from ERAU and one adjunct from GAC have taught in the program. Each term their opinions were solicited regarding the student performance, the compressed format, and the available resources for teaching at the World Wide Campus. In all instances the feedback has been very positive. The regular ERAU faculty comments are especially interesting since they gage their opinions from the perspective of the typical on-campus student performance. Statements like: "*The group of students was very impressive. They seemed to be exceptionally interested in the subject matter and were attentive and responsive, both in class and with external assignments. I think all course objectives were met by all students. The three project planning exercises conducted by groups of students were very well done and demonstrated accomplishment of much learning… The schedule worked well for the course, the students, the instructor, and the budget."* has been typical. Another metric sought was in the association of the academic scientist with the student and the engineers in general at Gulfstream. At present three faculty members have had substantial interaction with Gulfstream at a professional level, one has had notable prior industry experience, another reasonable exposure to industry and the third almost no involvement of substance – the academic scientist. This last individual is currently in residence with Gulfstream and has been there for nine months. He is working with their engineers part-time assisting with the validation of analytical engineering methods while also teaching in the MMSE. His response regarding his experience from being immersed into this professional working environment is particularly interesting: "*I have found that what we really learn or teach in engineering schools can be effectively applied to the problems in industry. We teach them the foundational topics very effectively. However, we tend to focus more on the classical topics directly from text books. It is also of paramount importance that we emphasis on the practical aspects of engineering and real world problems. Engineering environment and the pace of the industry today is different from the past, and foundational engineering topics are not sufficient in order to prepare our students for the work environment. It is also very important that we teach our students engineering ethics, effective communication,* *effective technical writing, and team work from the very first day of their freshman year. Fundamentals of engineering and introduction to engineering design should be introduced in the very first semester. Applied and conceptual physics as opposed to the traditional theoretical physics should be taught at the early stages. In addition, applied mathematics and basic engineering software and tools must be taught. We should also place emphasis on the numerical techniques as applied to engineering problems such as applied numerical methods, FEM, and CFD."*

In a similar fashion the Gulfstream professional who chose to step up and teach as an adjunct had some interesting observations: *"Extremely valuable experience - I enjoyed teaching and will continue to teach as much as I can. Teaching (at work or at a university) is something I would want to later in my career so I can give back my knowledge. Teaching co-workers is tough; I was not sure how to separate my work status with the professor status. This experience was quite humbling for me. I still have a lot to learn and must continue to expand my own knowledge base. I thought the workload would be a lot less than it was preparation before class was the key. I thought I knew the material quite well, I thought I was ready. I knew some of the material well and I could speak to it without review. Other parts I did not know well at all, I had to prepare for each class a lot more than I thought I would. Working with the students was a pleasure. It was good to see them learn and grow. It was really fun to see them solve problems I just made up - I feel I gained a special respect from this set of co-workers."* While anecdotal and limited, these comments resonate with the hypothesis offered earlier that there was much to gain for both organizations by working collaboratively. It is anticipated this trend will endure.

Another ongoing measurement connected to the affidavits is a brief ranking of skills and attitude attributes assessed by the professional participants, faculty teaching in the program- both before and after their experience, faculty with significant industry experience (SIE), and faculty with no industry experience (NIE).

a) Value of good communication
b) Mature intrapersonal skills
c) Managing conflicts
d) Time management skills
e) Job prioritizations ability
f) Solving mathematical problems
g) Formulating mathematical problems
h) Writing code
i) Writing prose
j) Designing graphical illustrations
k) Defining solutions to abstract problems
l) Listening ability
m) Observation skill
n) Creative thinking
o) Resourcefulness

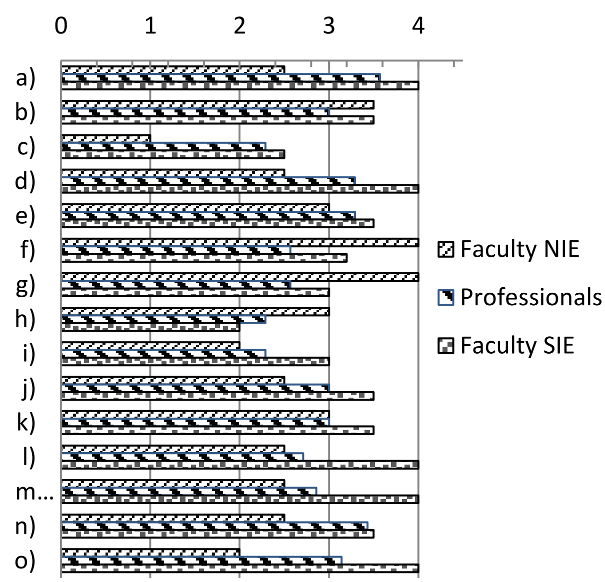

Figure 1 Valued Skills & Attitdudes

The pool of those who responded to the inquiry was statistically small (32 in all) but again the anecdotal value is seen to track consistently with what could expected based on the discussion herein regarding the cultural differences. The question asked to rank the following skill or attitudes using a scale of Very High, High, Moderate, and Low. Not surprisingly Figure 1 illustrates the results and shows that faculty SIE and the professionals are more in agreement than faculty NIE about importance of this attributes.

Value to Gulfstream

Industry Benefits from the emphases on engineering practice in product development benefits from not only student's immediate interests but also lends toward providing a mature, fortified, and capable engineering contingent within the Gulfstream organization while also giving the corporation a role in achieving a number of significant changes in engineering education in general. In the words of Tim Farley, now the GAC-VP of Engineering, "*We have already noted a change among the engineering employees at GAC with the MMSE program in place. Interest in the program is high. Those in the MMSE are connected to the company and have greater visibility in the upper management ranks. Tailoring of the curriculum content to focus on Gulfstream products and approaches, I feel, has already helped with stemming turnover and attrition we had seen in the past. Employees in the MMSE are notably motivated and have matured in their confidence of technical subjects. Their enthusiasm is catchy. The research component generates real interest among the employees involved and among our management.*

Value to COE
• Helps keep faculty current on professional applications, jargon and issues
• Provides a broad appreciation for disciplines beyond specific disciplines in engineering
• Gives working examples from which classroom material can be developed
• Enhances personal insights to academic theories and methods for students
• Heightens awareness of the interactions between functions within the industry
• Expands and enhances the reputation of COE within industry
• Enriches the capability to devise assessment measures for better education of the total person
• Provides insights to the current state-of-the-art practices, methods and codes used in the field
• Supplies the COE with first-hand knowledge of the job market and trends for advising students
• Improved skills mix within the COE's workforce

Value to the individual faculty member:
• Diverse and increased experiences
• Possible augmentation to remunerations
• Improved understanding of science, engineering and industry
• Resume, credential, and reputation enhancing
• Provides opportunities to maintain currency in regulatory issues, engineering methods, computer codes, etc.
• Increased contacts for future consulting work or student placements

Value to the University
The MMSE directly supports the mission statement of the University regarding preparing students for careers in engineering by providing the faculty with opportunities to develop expertise in application of engineering sciences to realistic situations. Additional experience serves to give the faculty examples useful in teaching and creating projects for students.

Enhanced professional reputation of the University can be expected and the MMSE provides vision with respect to University strategic planning. The curriculum content is compose entirely of existing graduate courses but is progressively being tailored to use Gulfstream examples and application in the content to address the professional educational needs of the participants and to assist in the development of Gulfstream's rapidly growing engineering workforce. This material represents learning opportunity for the faculty involved and has enhanced other courses they teach on campus in all the COE programs

While this program emphasizes interdisciplinary graduate-level engineering education in areas important to Gulfstream, it is also intended to provide the impetus by which graduate engineering courses can be offered by DL methodologies. It now serves as a model that can be expanded to other industry locations. Now that it is operational the MMSE program positions the ERAU on par with the majority of leading engineering institutions in the United States offering similar DL components with the added feature of also providing a setting the encourages Gulfstream's employee–students and ERAU faculty members to work on applications important to both organizations.

Summary and Conclusions

Understanding real constraints, realistic problems, and challenges are not often presented or faced in the class room environment. In the engineering practitioner's world practical applications and design syntheses skills are paramount. So are working knowledge of product development cycles, interdisciplinary technology infusion, and systems integration in a product environment often abundantly interwoven with the realities of manufacturing and heavily laden with market pressures, costs, expenses, schedules, and regulatory constraints. In contrast, since the late 1950's, engineering education, especially aerospace engineering education, has slowly replace practice and applied engineering with theory, computational methodologies, and research - all important to engineers but topics that best fit the arena of science - not professional practice. We are now confronted with a status quo where these two cultures of practice and education are so far apart in values, economics, schedules, performance metrics, motivational influences, and even in the jargon they speak that they are barely able to communicate in meaningful capacities much less work collaboratively and understand each other's needs. This is fundamental reason supporting the notion that collaboration between universities and industry is critical to filling the gap between the two cultures and ensuring the most meaningful learning takes place. Opportunities for college faculty to interact with industry are clearly very beneficial. Collaboration helps assure problems that are currently issues for industry are understood and addressed using means that are effective. At the same time, both faculty and students can benefit from experiencing realistic (and often time critical) challenges rather than textbook examples. The tie to real world problems provides a new level of motivation and excitement for students and faculty alike.

Involving industry practicing engineers, faculty, and neophyte students in collaborative settings has provided an environment where all the participants gain a greater understanding of the product development cycle and business environment and learning as well.   These intersections have provided a way to introduce students in real-world engineering. In addition the erudite faculty member, who often may have had only limited industry involvement, can be better informed as to the methods of application used by industry and the working environment that students they are teaching will find as part of their professional life. In addition these same academics may find, through their intimate involvement with their industry counterparts, that the theories and the applications are often far removed from one another. Seeing this setting as one way of remedying a crucial disconnect between what is taught, what is not, and what is needed within the U.S. aerospace engineering workforce has inspired Gulfstream and ERAU to broaden the scope and formality of the initiatives discussed in this paper and to share the findings with other in the aerospace community in hope that others can use the approaches and structure that has work so positively in this one instance. It is believed to be a sensible approach and a viable pedagogical model cast in a win-win proposition.

Since the MMSE originated with customer input, the benefits that this degree brings to the COE are well aligned with the University strategic needs as well as those of Gulfstream. Now beginning its third year, this experiment is viewed as wholesome and vibrant. Enrollments have yielded over 450 credits completed with a CGPA of 3.86 for the entire enrolled group. Opportunities in research for students and faculty have materialized currently with six thesis activities underway and five different ERAU faculty members. This faculty thesis involvement is considered funded research by the University and counts toward promotion and tenure. And Gulfstream is open to having publishing research results provided as long as now proprietary information is divulged. The value and insight for improving the company's competitive technology readiness is internally becoming more and more apparent to Gulfstream's management. Working professionals are participating as adjuncts and have experienced personal enrichment from the experience. We now have faculty members serving in residence as consultants. Experimental distance delivery technologies are finally gaining credibility within the college and a training program is underway to expand it usage. Student populations and course logistics has initiated some modest tweaks the program content but this is as it should be in an effort to continuously improve a product.

This degree is now viewed as a pilot program for ERAU, developed for a specific industry partner, Gulfstream, but it affords opportunities for further outreach with other aerospace and related engineering organizations. It has been one way to have those teaching engineering attained useful, practical, and pertinent experiences in the environmental frame-work like that of the graduates they teach. It also has generated opportunities that are suited to faculty predilections toward attaining scholastic achievement in funded research essential to their survival in the university environment and having it count toward advancement at the academy. The potential for further strategic outreach in the profession, this project provides an incentive for moving the COE into the DL environment in support of the University strategic plan and should do so with minimum risk and cost while initially establishing interactive linkage between working professional and engineering faculty.

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